



# K150 Radiation Effects Facility at the Texas A&M University Cyclotron Institute

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Accelerator Physicist / Project Manager

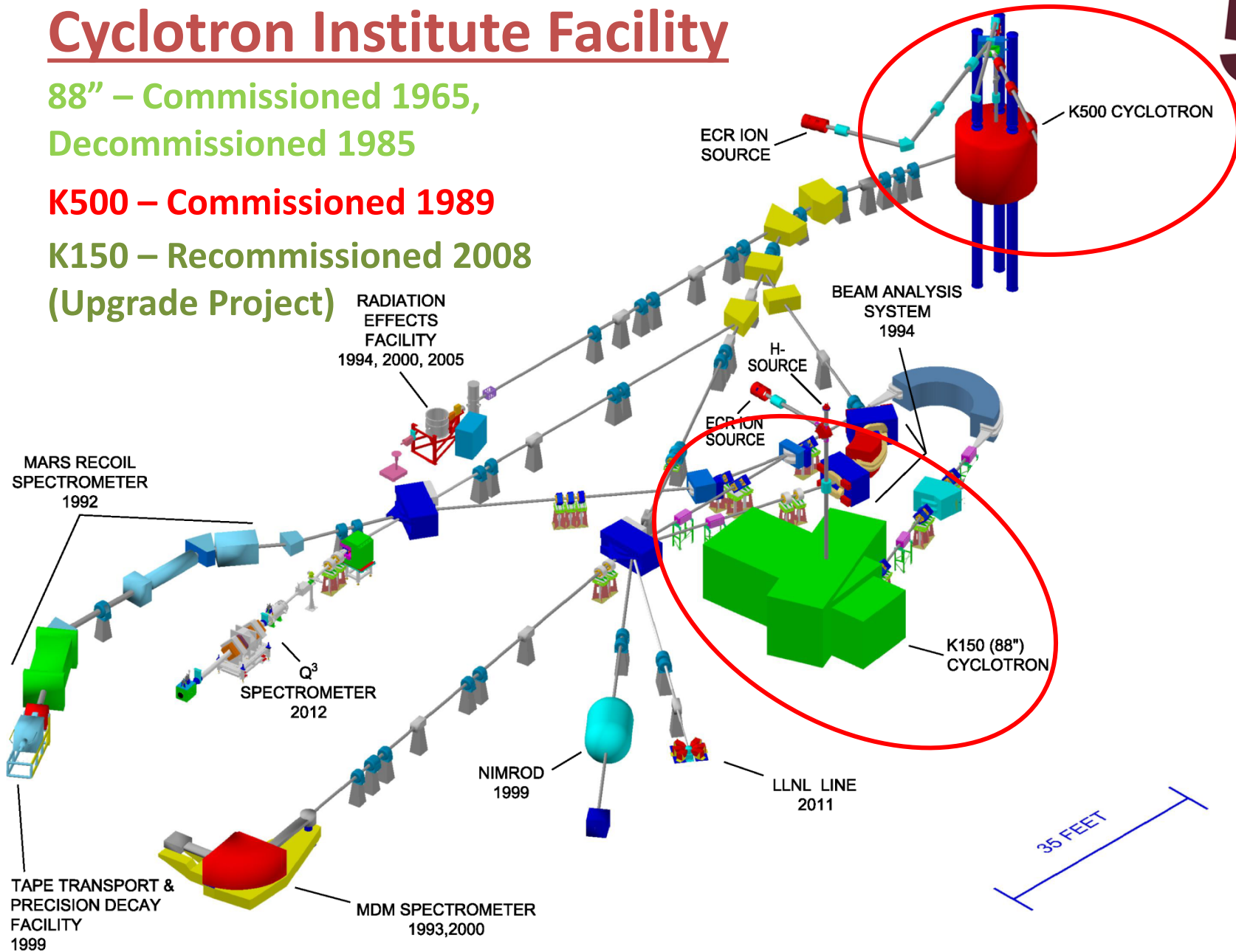
<http://cyclotron.tamu.edu/ref/>

# Cyclotron Institute Facility

88" – Commissioned 1965,  
 Decommissioned 1985

**K500 – Commissioned 1989**

**K150 – Recommissioned 2008**  
**(Upgrade Project)**



# Nuclear Science Programs at TAMU

Nuclear **Astrophysics** (Capture  $\gamma$  rates)

**Fundamental Interactions** ( $0^+ \rightarrow 0^+$

$\beta$ -decay Correlations)

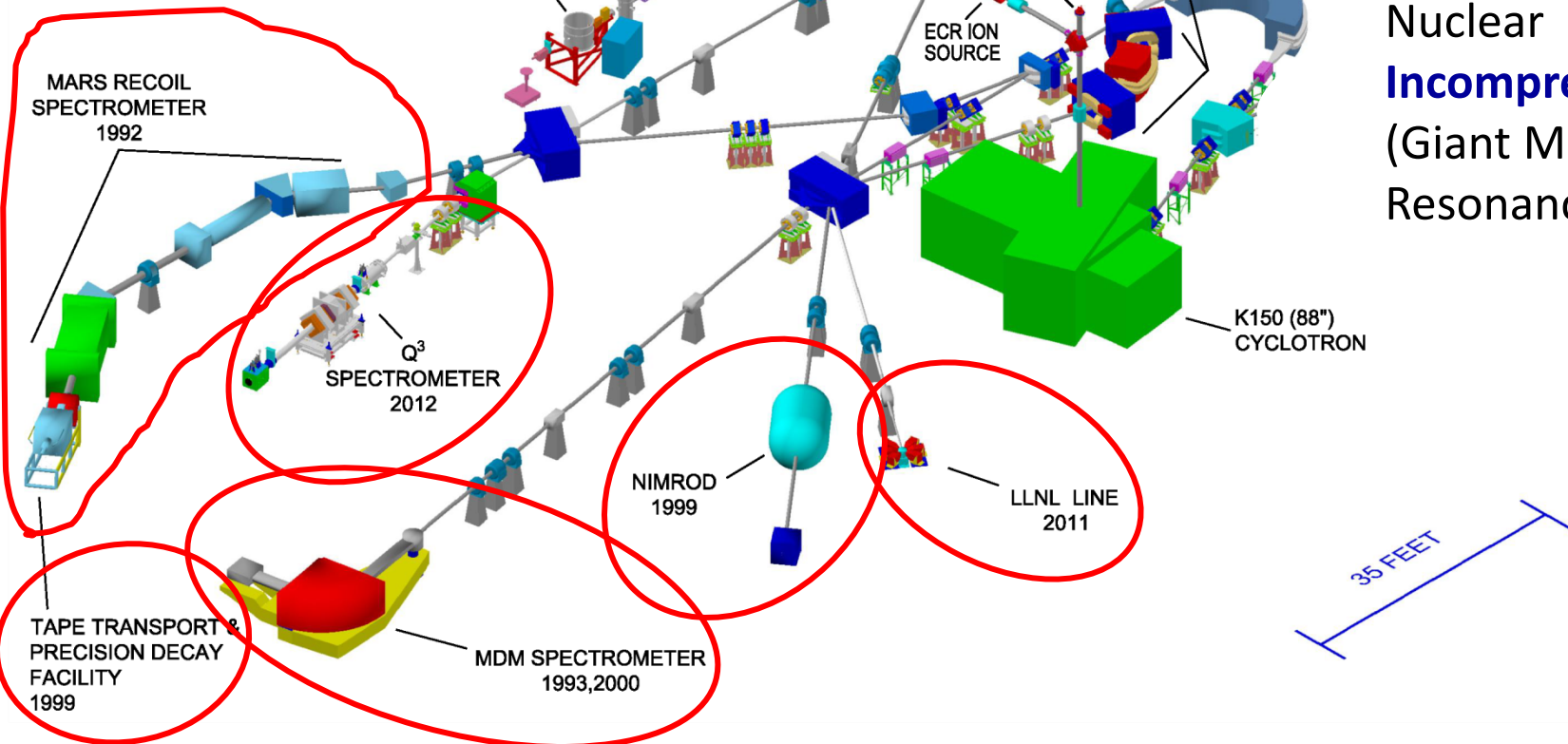
Nuclear **Dynamics** and **Thermodynamics**

(caloric curves,  
N/Z effects...)

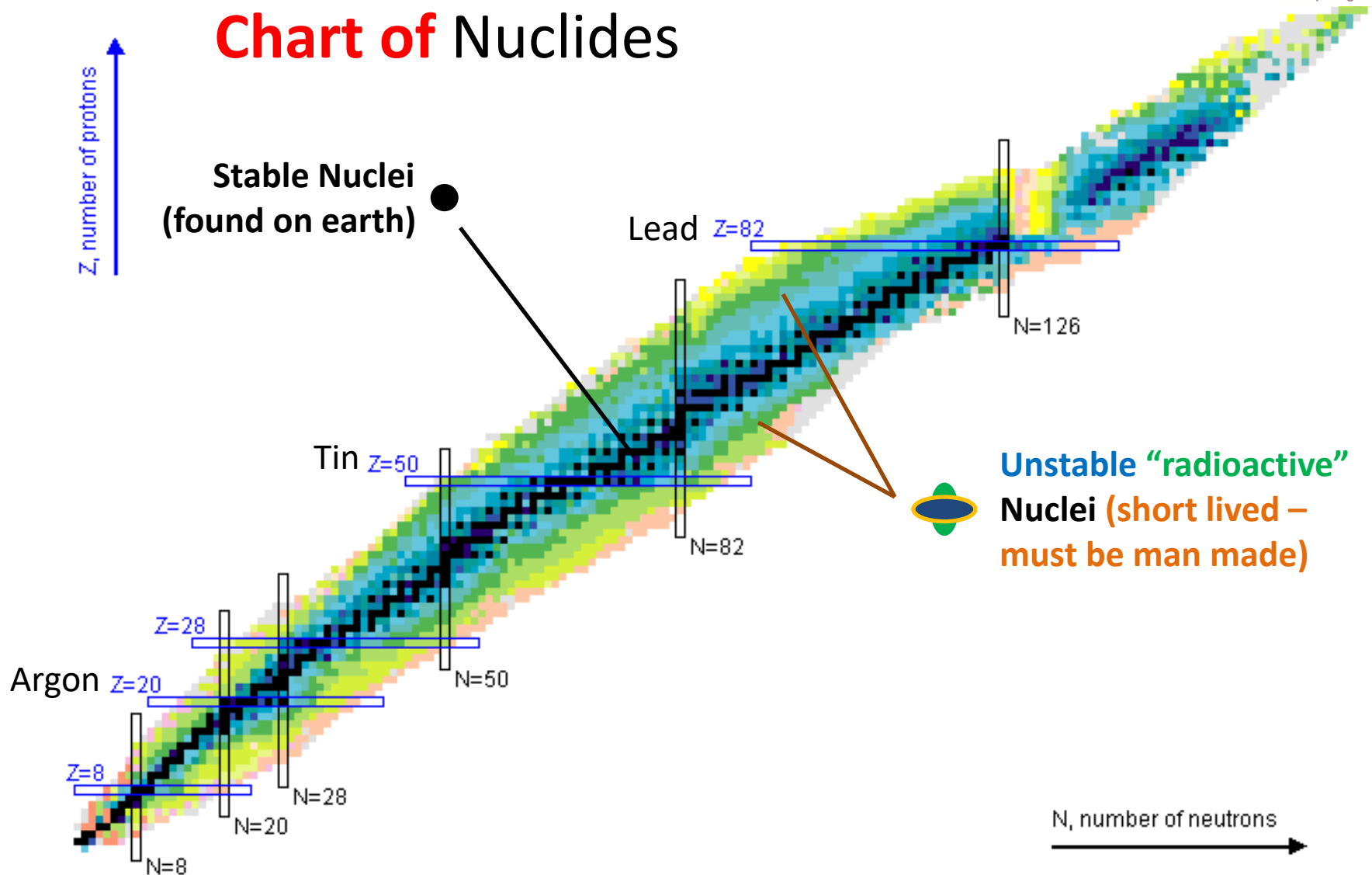
**Heavy element  
chemistry**

(Production of  
nuclei  
with  $Z > 100$ ...)

Nuclear  
**Incompressibility**  
(Giant Monopole  
Resonance)

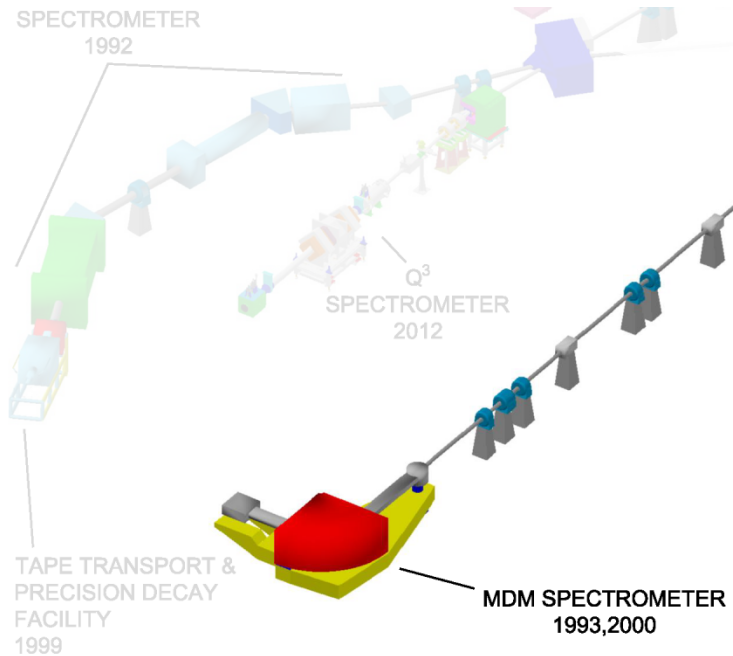
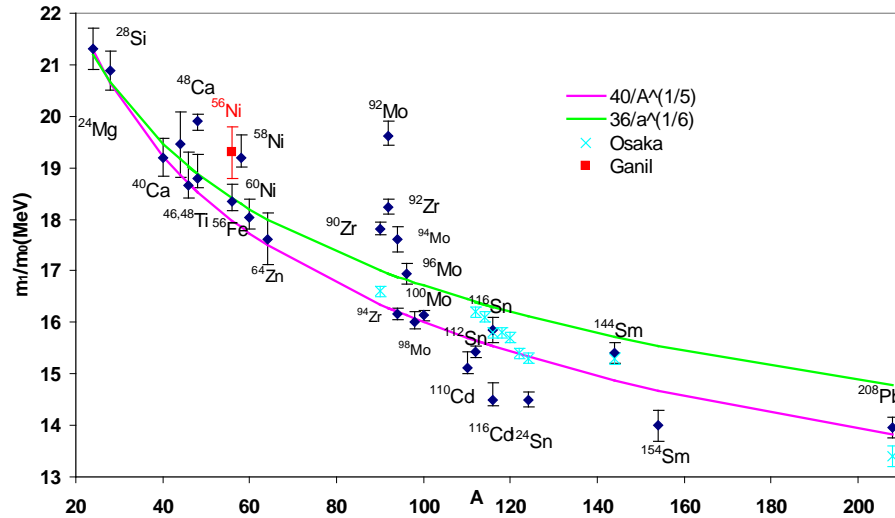


# Chart of Nuclides

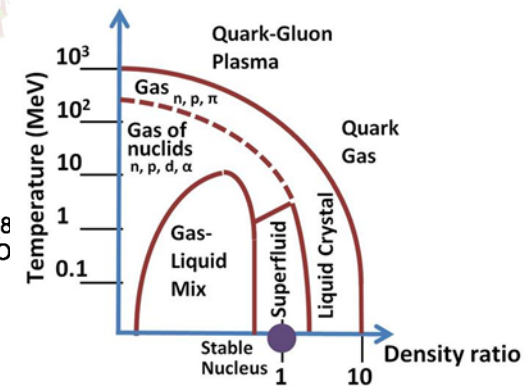




# First Experiments with $^{27}\text{Si}$ RIBs:



$E_{\text{GMR}} = (K_A / m \langle r^2 \rangle)^{1/2}$ , "Breathing mode" directly related to the Incompressibility of Nuclear Matter (important for EOS, density of neutron stars...)



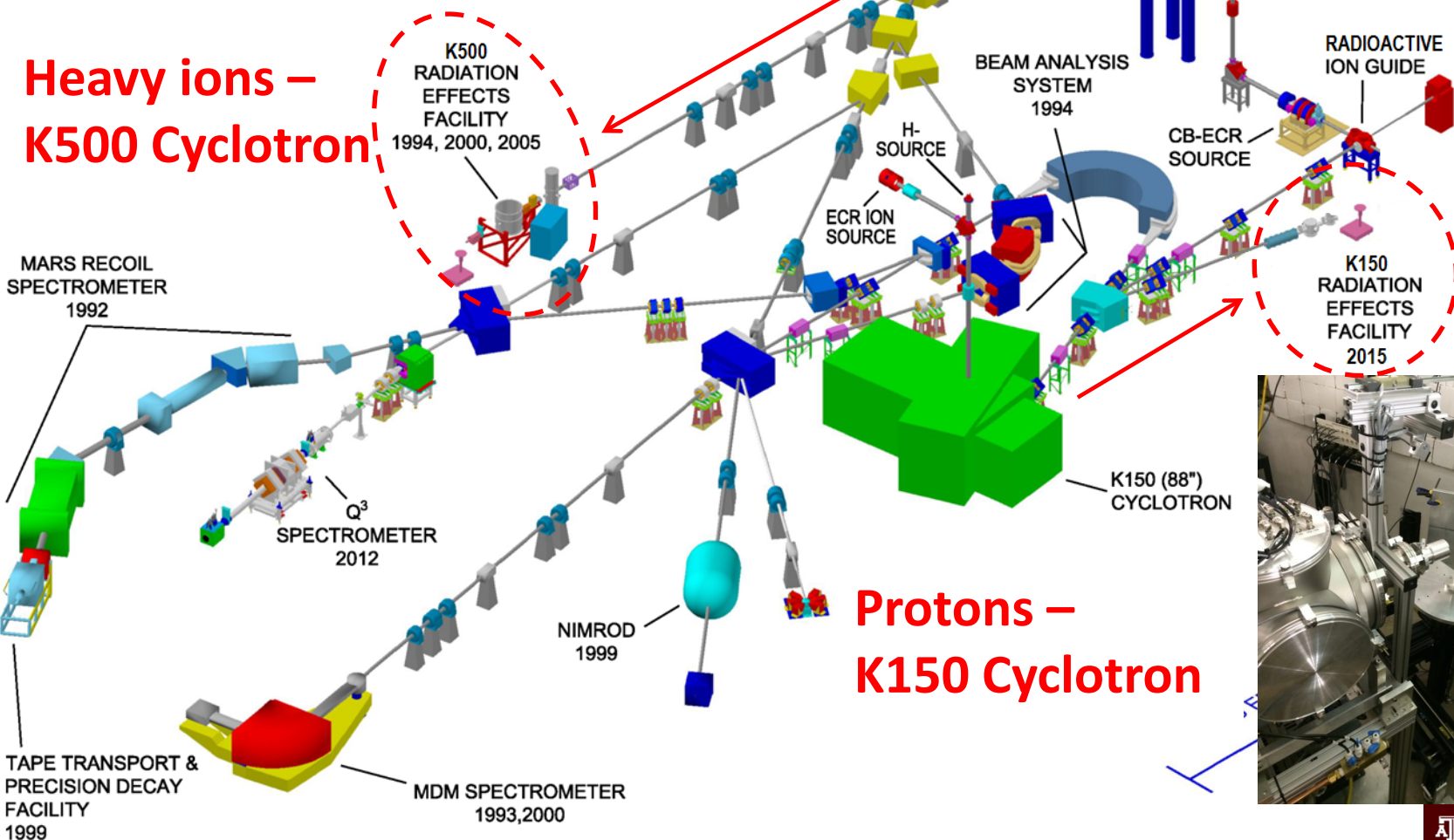
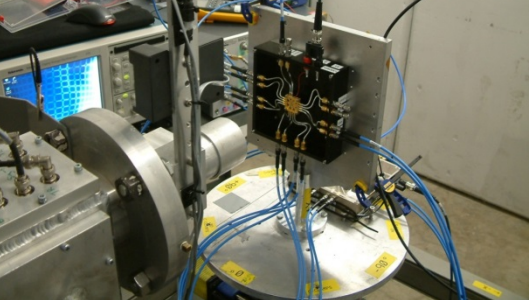
# Projected beam intensities from the Light Ion Guide after K500

(p,n)	Max Energy	Intensity
Product ( $T_{1/2}$ )	MeV/A	particles/s
$^{27}\text{Si}$ (4.16s)	57	$4 \times 10^4$
$^{50}\text{Mn}$ (0.28s)	45	$1 \times 10^5$
$^{54}\text{Co}$ (0.19s)	45	$4 \times 10^4$
$^{64}\text{Ga}$ (2.63m)	45	$2 \times 10^5$
$^{92}\text{Tc}$ (4.25m)	35	$2 \times 10^5$
$^{106}\text{In}$ (6.20m)	28	$4 \times 10^5$
$^{108}\text{In}$ (58.0m)	28	$2 \times 10^5$
$^{110}\text{In}$ (4.9h)	26	$4 \times 10^5$

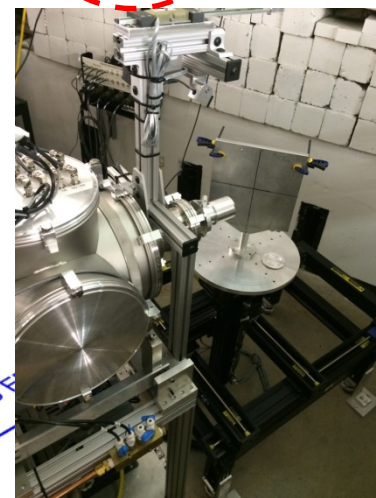
Assuming 14  $\mu\text{A}$  beam, realistic LIG, CBECR,  
transport and K500 extraction efficiencies

# Two REF Beam Lines at Texas A&M

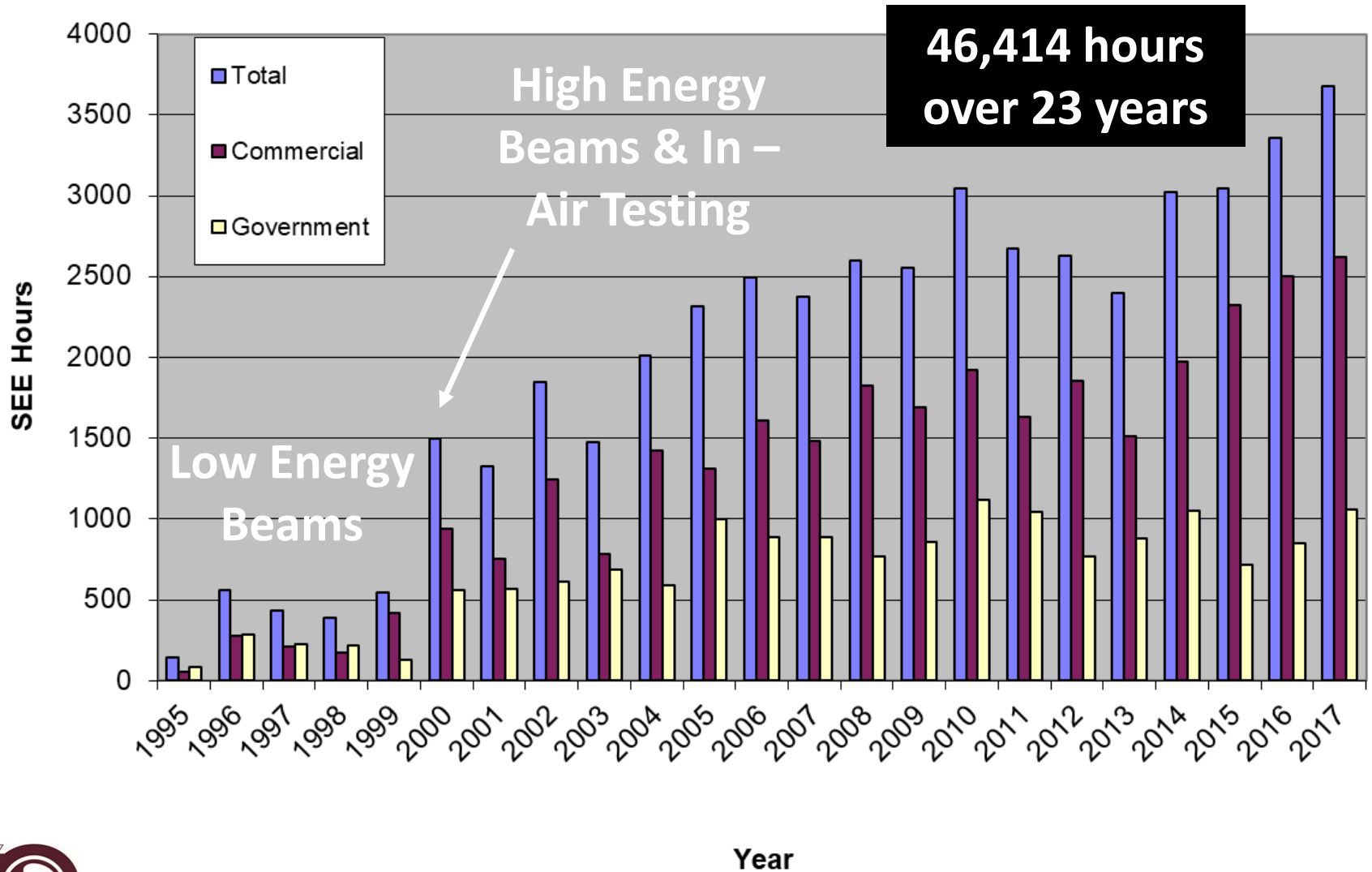
**Heavy ions –  
 K500 Cyclotron**



**Protons –  
 K150 Cyclotron**

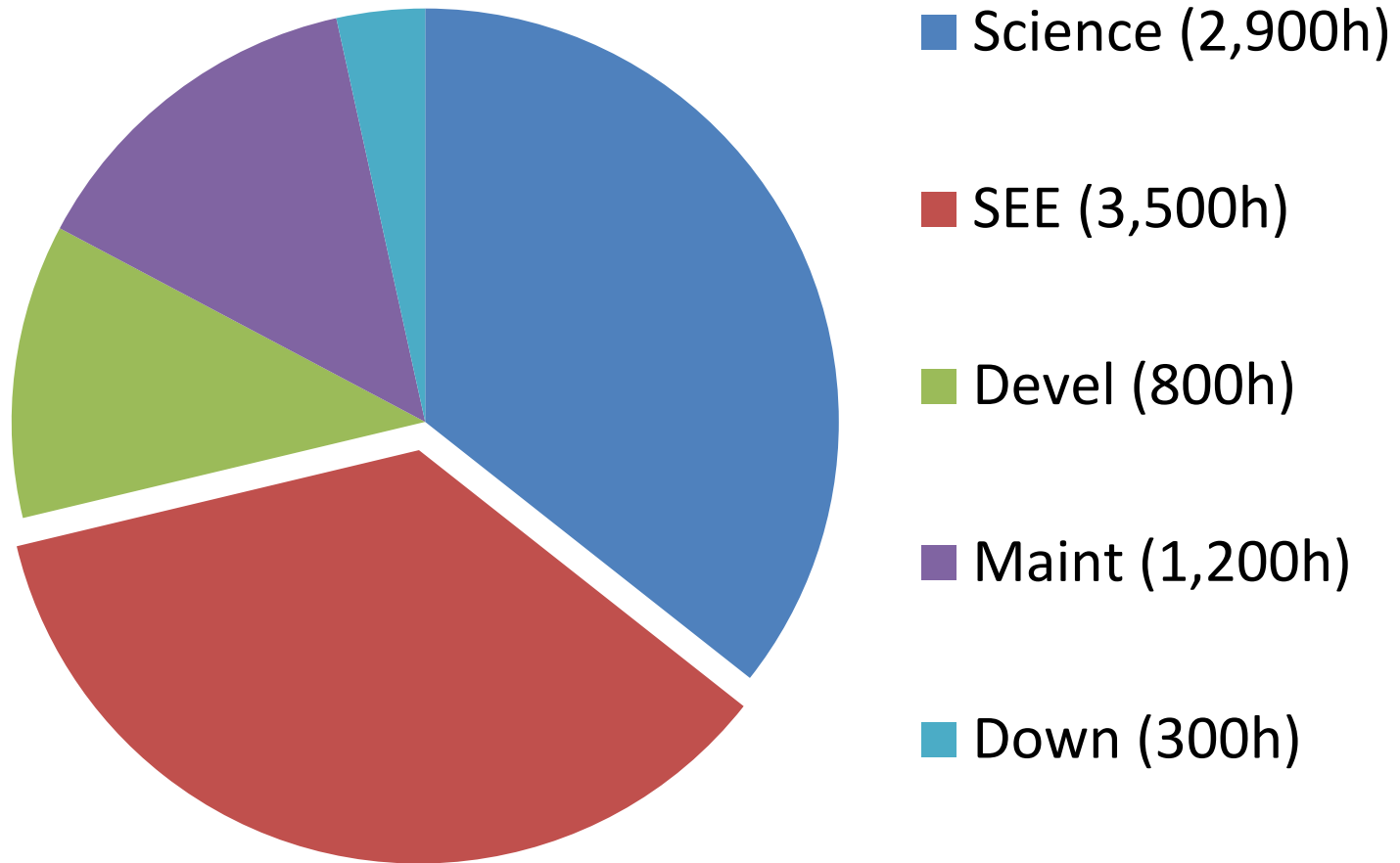


# K500 REF Hours at Texas A&M

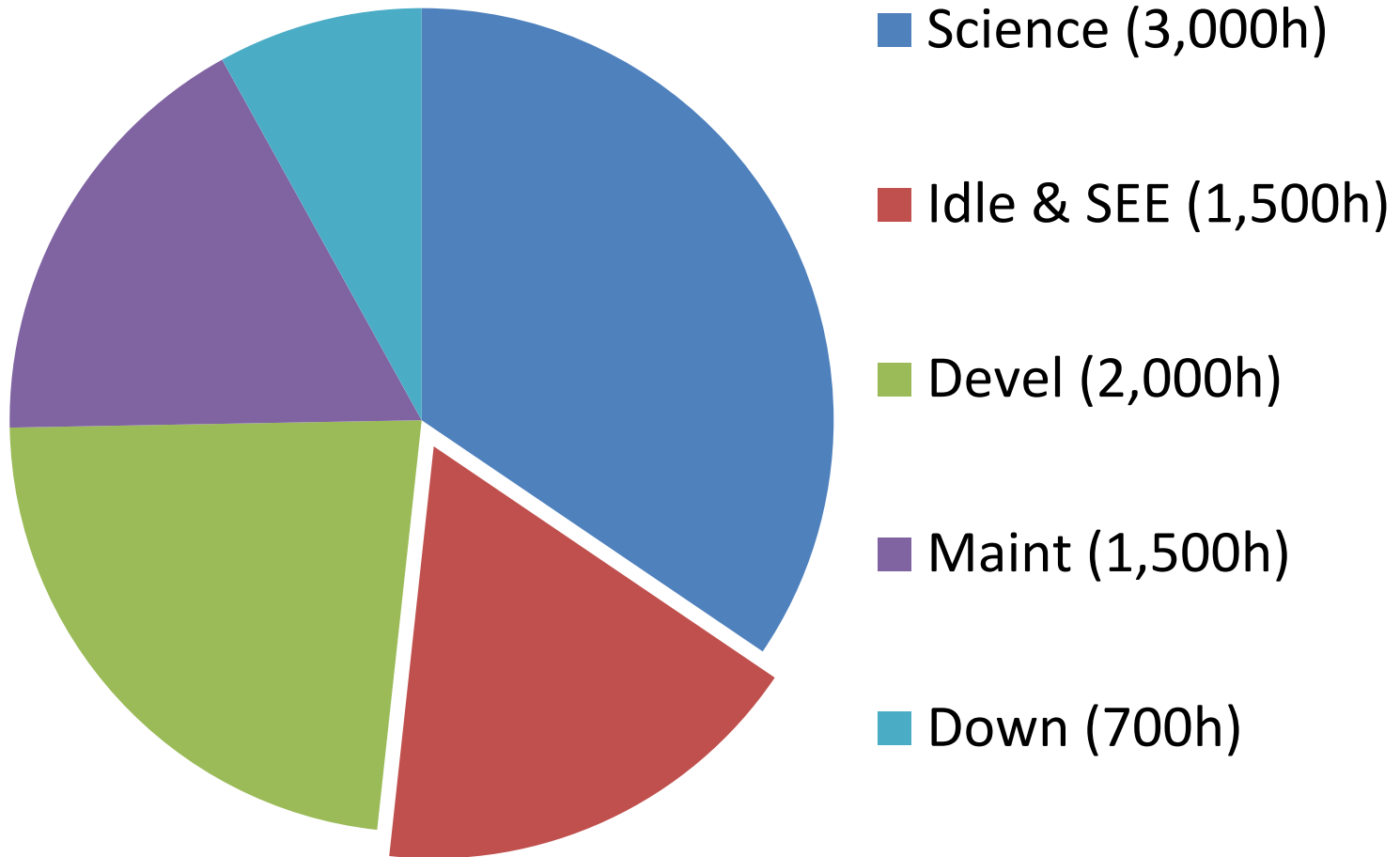




# K500 Operating Hours (~8,700h/yr)



# K150 Operating Hours (~8,700h/yr)



# K150 Cyclotron REF Information:

- 1...45 MeV protons (tunable/mono-energetic)
- Energy (RF system) changes ~30 minutes
- Energy degrader wheel for fast energy changes
- Flux adjustable between  $1\text{E}1 - 1\text{E}10$  p/s-cm<sup>2</sup>
- Uniform beam spots – 1" and 1.75" dia. (can be reduced to ¼" dia. with collimators)
- In-air testing station – 10" x 10" frame remotely controlled (x, y, z,  $\theta$ , roll angle)
- Cable length ~60' minimum
- ~300 testing hours in 2016, 2017

# K150 REF - Dosimetry System

- We provide diagnostic equipment for complete dosimetry analysis and beam quality assurance.
- Test control and monitoring is conducted with the same custom SEUSS software on both beam lines.

The screenshot displays the 'Seuss 2016' software interface, which is divided into several functional panels. The 'Current settings' panel on the left lists parameters such as Log file, Beam (43.7 MeV/u H @ K500), Al degrader (0.000), Layers (1 epoxy), Beam energy (43.7 MeV/amu and 44 MeV), Target material (epoxy(1.85)), Nominal LET (0.014 MeV/cm²/mg), Nominal range (9704.4 µm), Effective LET (0.014 MeV/cm²/mg), Effective range (9704.2 µm), Location (In-air), Position (Current), and Bias (V). The 'Cyclotron operator controls' panel in the center features buttons for Enable, Open S1, Close S1, Open S2, Close S2, Select log file, Select Beam, Set Hardware, Check Beam, Set Bias, Update, Change Setup, and Exit Program, along with a central 'ATM' logo and a 'Detector Shield' indicator. The 'User controls' panel on the right includes buttons for Layers (Define, Load, Edit), Control Positioning, Set Run Parameters, Set Options, Help, and Run, as well as a 'Reports (click to view)' list containing User file contents, Run summary, Layer details, Log file, User options, Current settings, Range table, and Beam history. A 'Comment' field and buttons for 'To Log File', 'To Test File', and 'To Screen' are also present. The 'Beam characteristics' panel at the bottom right shows Flux (7.71E+004 ions/cm²/s), Uniformity (99%), Central shift (1%), Axial gain (9.80E-001), Calibration factor (1.00E+000), and a status field. The 'Positioning coordinates' panel at the bottom left lists X, Y, Z, T, U, V, S, and R coordinates in various units. A 'Beam flux control (simulation only)' panel at the bottom left includes 'Increase', 'Decrease', and 'Show Attenuation Factor' buttons. The interface is titled 'CYCLOTRON INSTITUTE Radiation Effects Testing Facility' and includes a copyright notice for Vladimir Horvat (C) 2006-2016.

Seuss 2016

Current settings

Log file: User log file

Beam: 43.7 MeV/u H @ K500

Al degrader (mil): 0.000

Layers: 1 (epoxy) Summary

Beam energy (MeV/amu): 43.7

Beam energy (MeV): 44

Target material: epoxy(1.85)

Nominal LET (MeV/cm²/mg): 0.014

Nominal range (µm): 9704.4

Effective LET (MeV/cm²/mg): 0.014

Effective range (µm): 9704.2

Location: In-air

Position: Current

Bias (V): 300 300 300 300 300

Beam flux control (simulation only)

Increase Decrease

Show Attenuation Factor

Cyclotron operator controls

Enable

Open S1 Close S1

Select log file

Open S2 Close S2

Select Beam

Set Hardware Check Beam

Set Bias Update

Change Setup

ATM

Detector Shield

IN OUT

Exit Program

User controls

Layers: Define Load Edit

Control Positioning

Set Run Parameters

Set Options

Run...

Help

Reports (click to view)

User file contents

Run summary

Layer details

Log file

User options

Current settings

Range table

Beam history

Comment:

To Log File To Test File To Screen

Calibration factor:

Measure Set Lock

CYCLOTRON INSTITUTE  
Radiation Effects Testing Facility

Positioning coordinates

X: 0.176 in

Y: -0.062 in

Z: -40.838 cm

T: 0.372 deg

U: -14.037 deg

V: 1.500 in

S: -0.000 steps

R: 0.000 deg

Beam characteristics

Flux (ions/cm²/s): 7.71E+004

Uniformity (%): 99

Central shift (%): 1

Axial gain: 9.80E-001

Calibration factor: 1.00E+000

Refresh in 2290 cnts

Status:

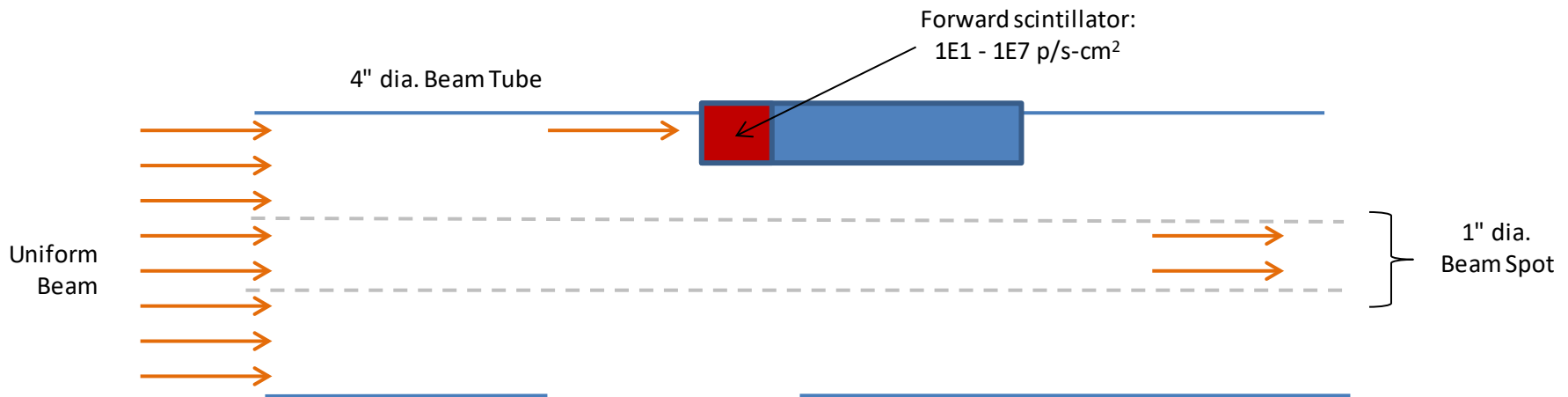
Clear

User: Henry (HENRY-PC)

Vladimir Horvat (C) 2006-2016

# K150 REF - Dosimetry System

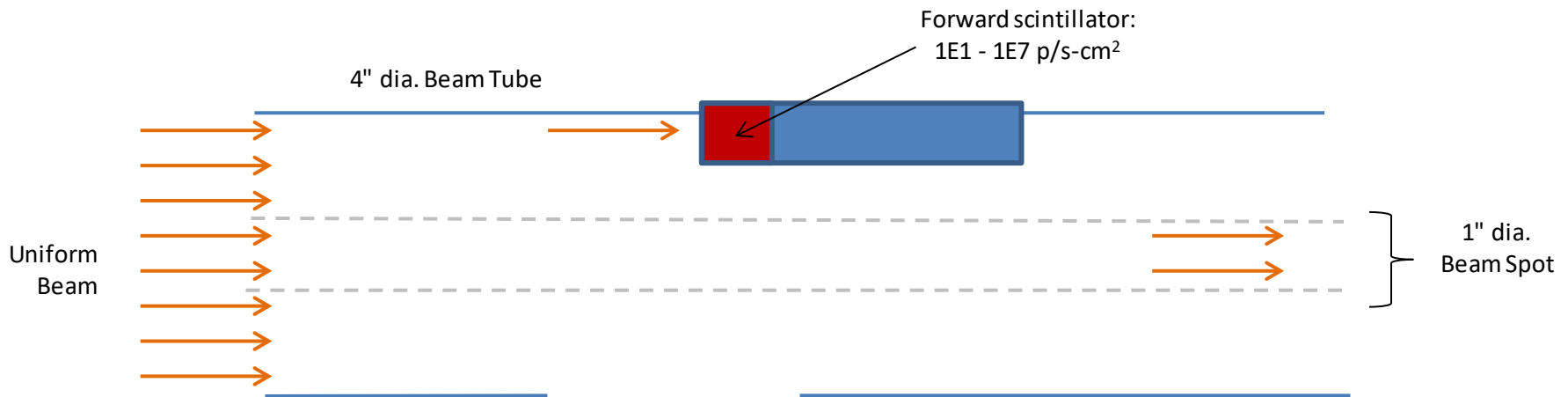
- Dosimetry at low flux ( $1\text{E}7$  p/sec-cm<sup>2</sup> and lower) is conducted using an array of five detectors comprised of plastic scintillators coupled to photomultiplier tubes.





# K150 REF - Dosimetry System

- For higher fluxes, uniformity is first adjusted at a lower flux and then a series of four Ta foils are used to backscatter protons into four additional detectors.
- After a calibration measurement, dosimetry is conducted using these back-scattered measurements.

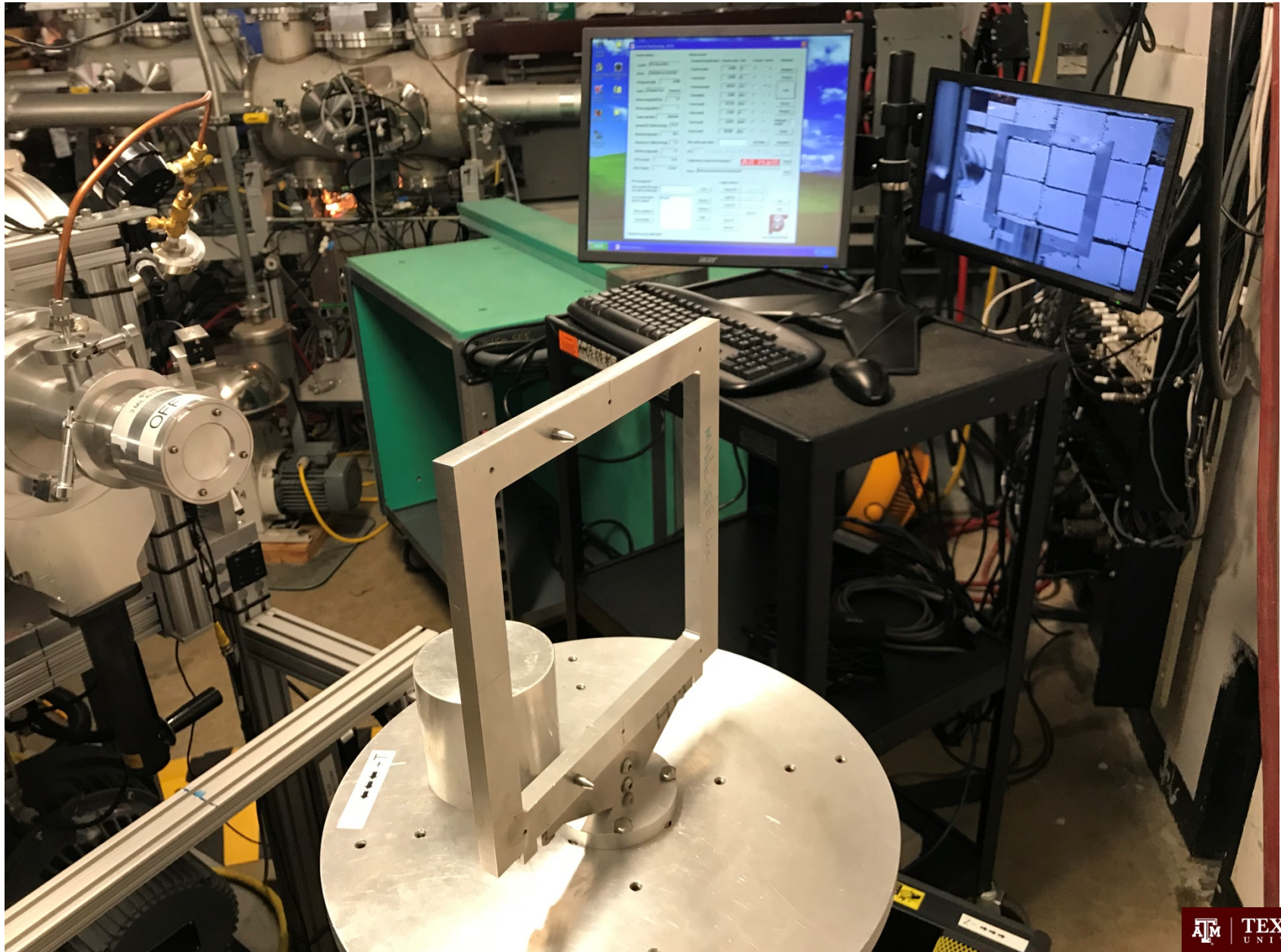


# K150 REF Beam Line





# K150 REF End Station



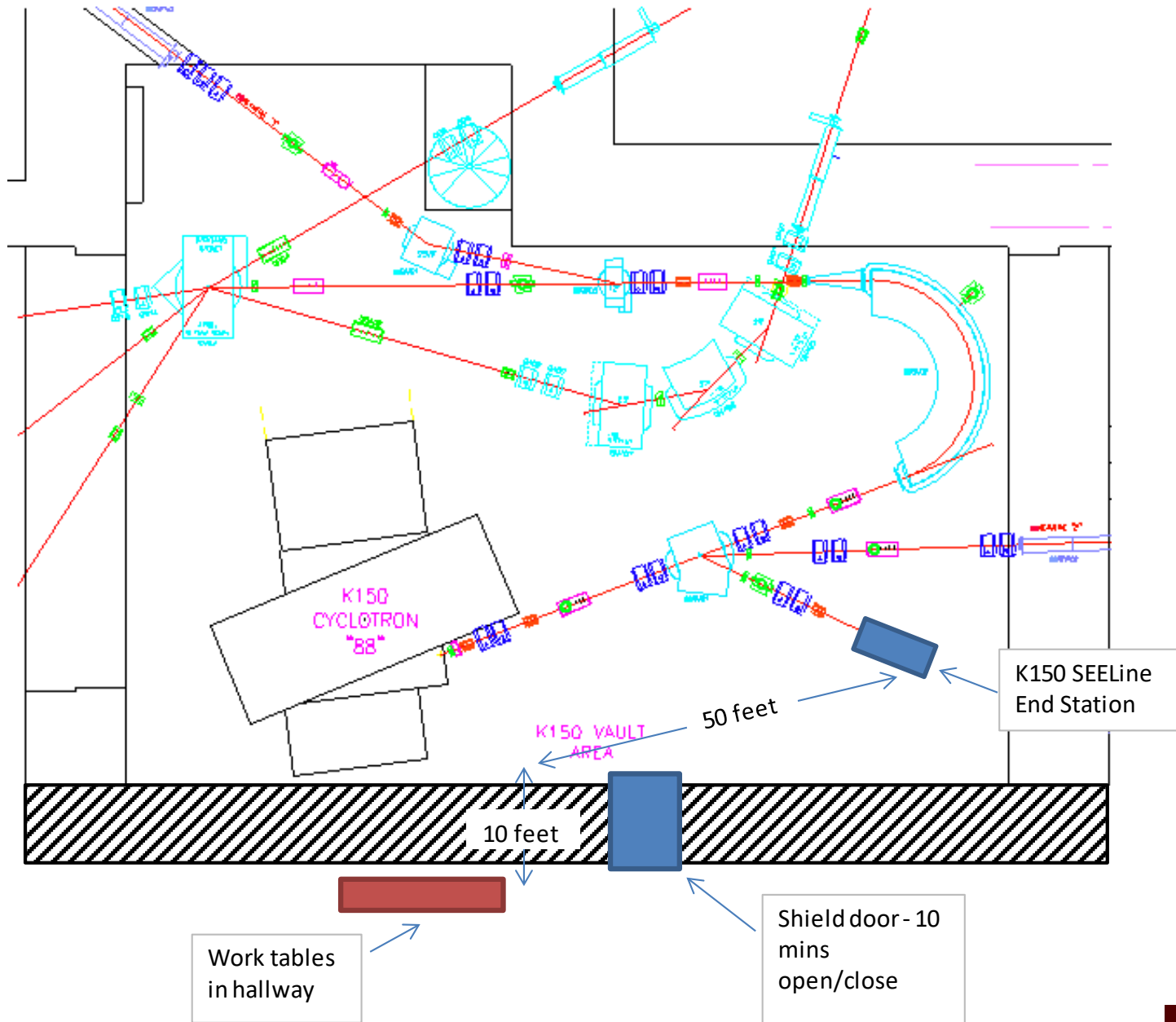
# K150 REF Neutron Shielded Equipment Carts

- 3" thick borated polyethylene.
- 4 carts available.





# K150 REF – Building Layout



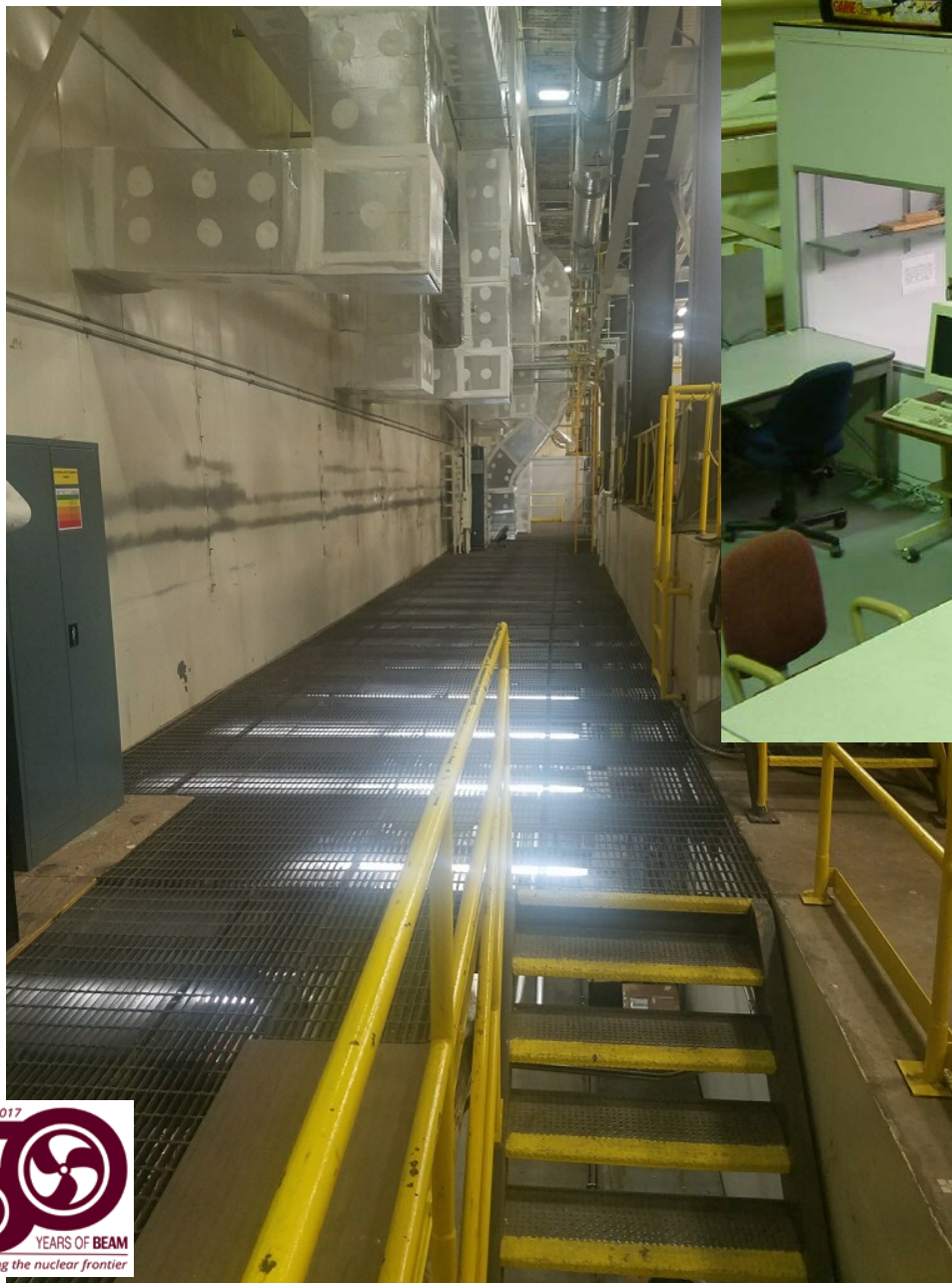


# “New” K150 REF Neutron Shield Door

- 60 second Open/Close time.
- 6” thick borated polyethylene.
- Operational by the end of May 2018.



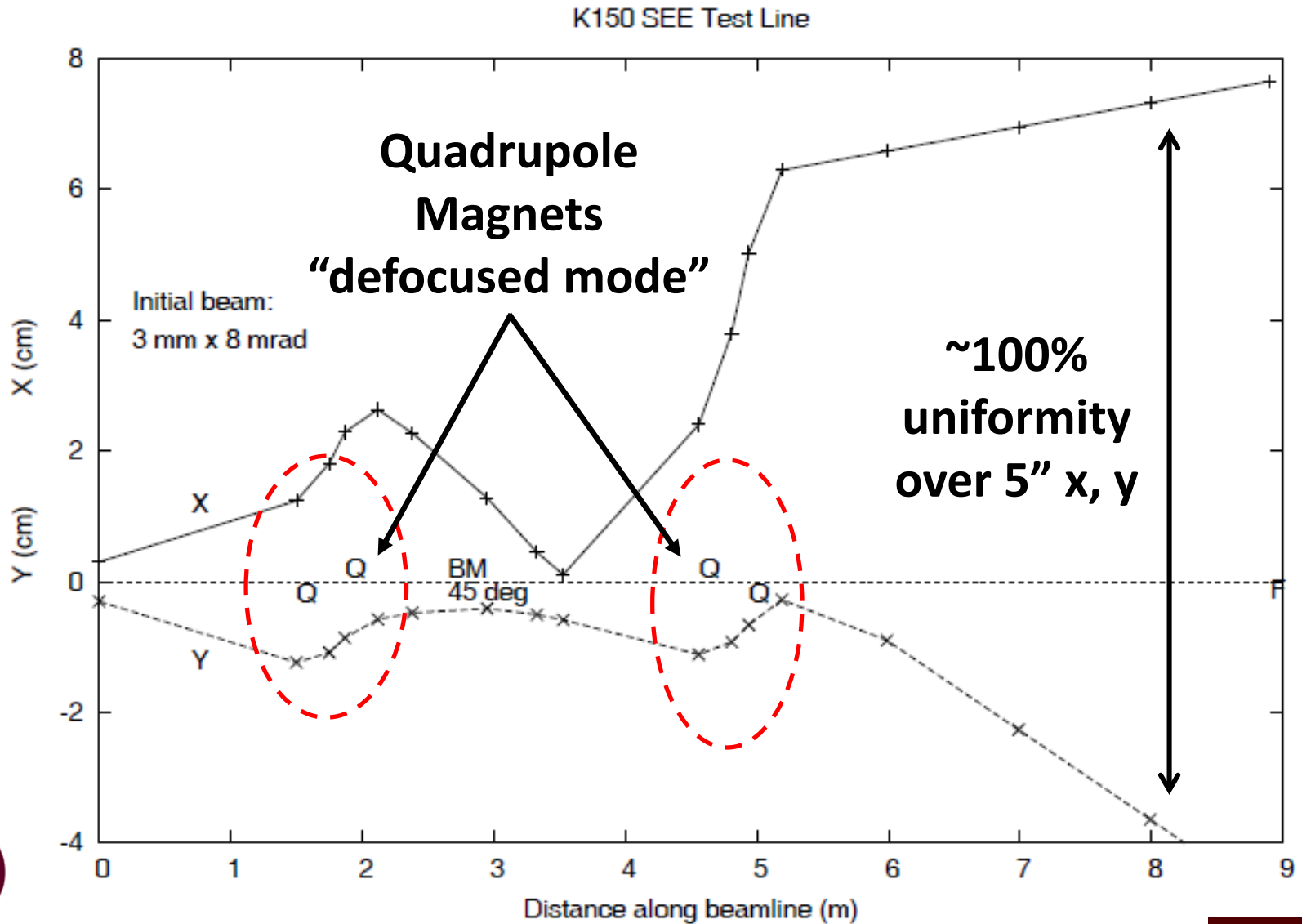
# “New” K150 REF Data Room and Setup Area



- Same as K500 REF area.
- Doorway to be added for service elevator use.
- Cableway thru wall.
- Ready spring 2019.



# “New” 5 inch Diameter Beam Spot



# K150 REF Heavy Ion Beams “soon”

- ECR produces a wide range of heavy ions (p – Au).
- Extracted 15A MeV Cu & lighter.
- Cyclotron vacuum & injection system improvements needed.
- Driven by science.
- Ready 2020?





Visit our website at  
<http://cyclotron.tamu.edu/ref/>

Questions, contracting, scheduling  
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